



US009636174B2

(12) **United States Patent**
Zarins et al.

(10) **Patent No.:** **US 9,636,174 B2**
(45) **Date of Patent:** **May 2, 2017**

(54) **METHODS FOR THERAPEUTIC RENAL NEUROMODULATION**

(71) Applicant: **Medtronic Ardian Luxembourg S.a.r.l.**, Luxembourg (LU)

(72) Inventors: **Denise Zarins**, Los Gatos, CA (US); **Hanson Gifford, III**, Woodside, CA (US); **Mark Deem**, Mountain View, CA (US); **Douglas Sutton**, Pacifica, CA (US); **Howard R. Levin**, Teaneck, NJ (US); **Mark Gelfand**, New York, NY (US)

(73) Assignee: **Medtronic Ardian Luxembourg S.a.r.l.**, Luxembourg (LU)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/059,332**

(22) Filed: **Mar. 3, 2016**

(65) **Prior Publication Data**

US 2016/0250460 A1 Sep. 1, 2016

Related U.S. Application Data

(63) Continuation of application No. 14/549,229, filed on Nov. 20, 2014, now Pat. No. 9,308,044, which is a (Continued)

(51) **Int. Cl.**
A61N 1/05 (2006.01)
A61N 1/32 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **A61B 18/1492** (2013.01); **A61M 5/14276** (2013.01); **A61N 1/05** (2013.01);
(Continued)

(58) **Field of Classification Search**

CPC A61N 1/0551; A61N 1/05; A61N 1/36017;
A61N 1/36117; A61N 1/36121;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,130,758 A 9/1938 Rose
2,276,996 A 3/1942 Milinowski
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2384866 4/2001
CA 2575458 3/2006
(Continued)

OTHER PUBLICATIONS

Page, I.H. et al., "The Effect of Renal Denervation on Patients Suffering from Nephritis," J. Clin Invest. Jul. 1935; 14(4): 443-458.
(Continued)

Primary Examiner — Mark W Bockelman

(57) **ABSTRACT**

Methods and apparatus are provided for treating hypertension, e.g., via a pulsed electric field, via a stimulation electric field, via localized drug delivery, via high frequency ultrasound, via thermal techniques, etc. Such neuromodulation may effectuate irreversible electroporation or electrofusion, necrosis and/or inducement of apoptosis, alteration of gene expression, action potential attenuation or blockade, changes in cytokine up-regulation and other conditions in target neural fibers. In some embodiments, neuromodulation is applied to neural fibers that contribute to renal function. In some embodiments, such neuromodulation is performed in a bilateral fashion. Bilateral renal neuromodulation may provide enhanced therapeutic effect in some patients as compared to renal neuromodulation performed unilaterally, i.e., as compared to renal neuromodulation performed on neural tissue innervating a single kidney.

15 Claims, 11 Drawing Sheets

